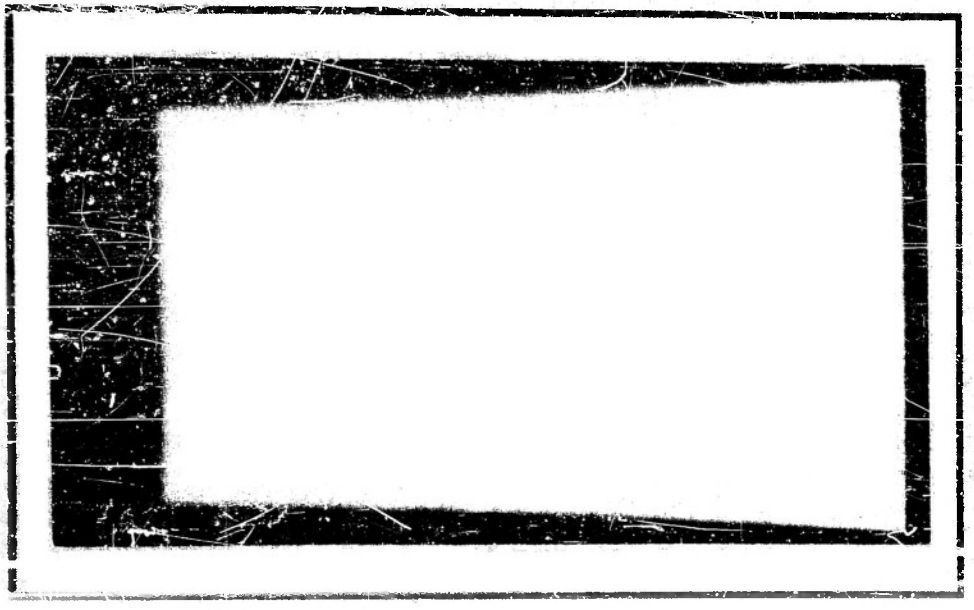

Microwave Laboratory
STANFORD UNIVERSITY
STANFORD, CALIFORNIA

INVESTIGATION OI HIGH-POWER KLYSTRONS

U. S. Navy Contract No. N6onr 25123

Code No. NR 073 361

STATUS REPORT

1 September, 1953 to 30 November, 1953

M. L. Report No. 226

January, 1954

Prepared by: The Staff of the
Microwave Laboratory

Approved by: E. L. Ginzton, Director
Microwave Laboratory

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Contract N6onr 25123
1 September, 1953 - 30 November, 1953

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(x) Part time compensation during any or all of the period.
(+) Full time compensation, entire period.

TECHNICIANS - MONTHS TOTAL FOR PERIOD

Electronics Technicians	4
Mechanicians	8
Tube Technicians	1/2
Drafting	1/2

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...ODUCTION AND SUMMARY

The period covered by the present report is 1 September to 30 November, 1953. The progress of the major projects is summarized in this section; the details are described in subsequent sections.

1. ACCELERATOR KLYSTRONS. Of the seven klystron failures during this period, only one was due to a window fault. A new type of oscillation has been observed and is being investigated.

2. BASIC STUDIES. The special klystron is still operating in conjunction with the Mark III accelerator.

The hollow-beam gun tester has been modified and is ready for additional tests.

A klystron with the high-voltage collector has been tested and the results are being evaluated.

A report on the gradient-focusing project is in preparation.

3. TRAVELING-WAVE KLYSTRONS. Experiments with the gridless tube have been concluded.

The gridded tube has also been tested and shows appreciable r-f leakage between buncher and catcher.

4. PULSED TRAVELING-WAVE TUBE. Additional modifications have been introduced and several new parts are being fabricated.

5. MILLIMETER-WAVE GENERATION. Additional equipment is being constructed for this project.

II. ACCELERATOR KLYSTRONS (Staff: J. H. Jasberg)

During this period seven klystron failures have occurred, of which three had damaged seals, two had bad heaters, one was poisoned by leaky output windows, and one had low output.

These seals are some of a bad lot which have gradually been failing under use. Use of the new type, described below, should eliminate this trouble. The heaters are also of the old type. No failure of the modified structure has yet occurred. The reason for low output has not been determined, but may be

due to a partially poisoned cathode. There have been two window failures; one was due to faulty construction, the other (on the Mark II accelerator) has not been examined, as noted below.

The accelerator was disassembled for repairs and extension, which gave us a chance to evaluate the performance of the tubes in operation and remove those whose performance was doubtful. This check resulted in replacement of four more tubes for repairs. A major difficulty which has appeared is the discovery of several tubes in which the upper output gap had been badly chewed by the beam, possibly as a result of misalignment of the focusing fields with respect to the tube, although this theory has had no conclusive support. A method of improving alignment has been devised and will be incorporated in the tubes. One of the damaged tubes was re-processed and is operating normally.

A new type of oscillation has been observed in some of these tubes. This oscillation occurs in the cathode-anode region of the tube and is of the Llewellyn 'diode' type. A mode corresponding to this frequency (2450 Mc/s) has been discovered in this region. Calculations of a cylindrical cavity having a height equal to the anode-cathode spacing and with a radius equal to cathode focusing shield also gives an answer close to the observed frequency. A crude calculation of transit time gives a result which agrees qualitatively with Llewellyn's theory. None of the above explains why the magnitude is so different from tube to tube. We first observed this oscillation in a tube by discovering a pronounced drop in beam pulse height during the second microsecond. This corresponded exactly to the time the oscillation existed as determined by a probe introduced into the oil tank near the high-voltage seal. The strength of fields required for such a drop must be very high and the amplitude must depend in some way on the coupling to the oil tank since the 'cavity' is strongly coupled to the rest of the cathode support and the high-voltage seal. There is a definite voltage mode of this oscillation which permits operation of tubes where the trouble does not occur. Fortunately this upper limit occurs just below the voltage where the tubes have been operating on the accelerator. We hope to get more data on this phenomenon both in cold tests and during the routine processing of tubes for the accelerator.

Modifications: We are converting tubes needing a main seal repair to a new type of kovar-to-glass seal which will eventually replace all the present Housekeeper-type seals.

The new seal is more sturdy and features a take-apart joint, which simplifies repairs. The corona rings are also stronger and more accurately located in this new seal structure.

III. BASIC STUDIES

A. SPECIAL KLYSTRON, K-14 (Staff: J. H. Jasberg)

No additional high-power tests have been made on this tube. The tube is still operating and has been used on the Mark III accelerator and for tests of focusing-coil alignment.

The other modified tube is still operating on the Mark II machine, although it now has a leaky window. This window has not been examined to determine the cause of failure, since such a check would involve possible loss of the tube in the process of changing windows. This examination will be made as soon as it is necessary to let the machine down to air.

B. HOLLOW-BEAM STUDIES* (Staff: M. Chodorow, C. Süsskind)

The beam tester has been assembled again, and is now on the vacuum pump, preparatory to further tests. If the hollow-beam electron gun proves successful, additional, more quantitative tests will be carried out with the help of a more elaborate tester now being constructed at the Electronics Research Laboratory under a grant from the Eitel-McCullough Company of San Bruno, California.

C. REDUCED-VOLTAGE COLLECTOR (Staff: R. H. Winkler)

Tests are completed on a two-cavity klystron with a special collector designed to recapture some fraction of the beam power following the r-f section of the tube. The collector is segmented into four parts by three high-voltage seals. Three segments are connected to taps on the pulse transformer, and the fourth is grounded to the r-f section of the tube. Electrons approaching the high-voltage segments are slowed down and deliver energy to the pulse transformer. This increases the effective impedance and effective efficiency of the tube.

It was discovered that very little is gained by using more than one high-voltage segment. There is an optimum voltage for a single-segment collector at which the product

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*This project is supported under Contract N6onr 25132.

of current collected and collector voltage is at a maximum. This optimum voltage is about 70 per cent of beam voltage and the collected power is 23 per cent of the beam power.

If there is no r-f drive on the tube, 62 per cent of the beam power can be collected. Eighty-five per cent of the beam current is transmitted to a grounded collector with no r-f drive and fifty-seven per cent with optimum loading and r-f drive.

Perhaps by decreasing the distance from the output gap to the collector bucket, a device could be built that would collect more than 23 per cent of the beam power.

D. GRADIENT FOCUSING (Staff: M. Chodorow, C. W. Barnes, Jr.)

This project has been terminated, and a technical report is in preparation.

IV. TRAVELING-WAVE KLYSTRONS
(Staff: E. L. Ginzton, H. J. Shaw, C. L. Hsieh)

A. GRIDLESS TUBE

A new cathode with narrower emission surface has been tried, in an attempt to increase the current transmission to the catcher. By rotating the gun structure during operation, the transmission could be optimized, but was found to be no better than before.

It is felt that unless the transmission can be made nearly perfect, it will not be possible to obtain good enough r-f behavior to make this tube practical. This is believed to be due to concentration of the r-f current near the surfaces of the beam. The present construction does not allow precise dimensions to be held throughout the beam space. No further experiments are planned for this tube.

B. GRIDDED TUBE

Insulation-coated heaters have been tried. The measured d-c characteristics are very satisfactory and close to design values. The temperature of the lowest row of grids (closest to the cathode surface) seems to be the limiting factor in the power-handling capacity of the tube. These grids were constructed with materials different from those of the other grids in the tube.

The results of r-f measurements have indicated that there was appreciable r-f leakage between buncher and catcher

waveguides. The leakage was large enough to make quantitative measurements of the r-f behavior impractical. By a series of r-f cold tests it was established definitely that the leakage path was through the drift space and the grids which close the drift space at bottom and top (not through junctions at couplers at ends of waveguides).

The tube has been disassembled. An attempt will be made to decouple the buncher and catcher guides sufficiently by inserting a mesh grid across the drift space at its center. The previous staff is at present devoting very little time to this project. Plans are to continue the program until completion, but at a considerably reduced rate. At present, a few new grid sections are being made, to replace certain grids mechanically damaged by accident.

V. PULSED TRAVELING-WAVE TUBE*

(Staff: M. Chodorow, E. J. Nalos)

Modifications following original tests are progressing. A new cathode is almost completely assembled, additional focusing coils have been built, and a new insulated collector is being assembled. The improved coupler design is still being worked on. The main disk-loaded tube was found to have appreciable reflections at the points of insertion of attenuating tubes. These reflections have been largely removed by slugging, using nodal shift techniques. A new tube designed for higher voltage is currently being electroformed, using somewhat modified disks and single-point suspension of attenuating rods. It is hoped that this tube will be assembled, using gold diffusion seals. Exploratory work on the possibility of periodic focusing using permanent-magnet ceramics is being explored.

VI. MILLIMETER-WAVE GENERATION

(Staff: H. Motz, W. Thon, R. N. Whitehurst)

During the period under review more work was done on constructing equipment. The gun was tested and improvements which were found necessary were made. It is hoped that the L-cathode will be satisfactory under the vacuum conditions of the experiments. At present reactivation seems necessary after a rest period. Work was started on a field-emission cathode. The first attempt to make a three-cavity prebuncher was not successful. Another one is in the process of assembly. Some work was done on calibrating and testing the echelon

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*This project is partially supported under Contract N6onr 25132.

spectrometer. A K-band klystron was obtained and higher harmonics were generated by means of a crystal multiplier. The power loss in the spectrometer at second-harmonic frequency was small and the angle measurement agreed approximately with prediction. The Medical Accelerator group has completed the electroformed buncher sections but the first attempt to make a stainless-steel coupler was not successful. We are awaiting their final assembly and tests. Some difficulty was experienced with our magnetron pulser at high repetition rate. Since high mean power seems desirable for our experiments, it was decided to modify the pulser in order to insure satisfactory operation at high repetition rate. This work is almost completed.

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